

75th MORSS 712CD Cover Page

12-14 June 2007, at US Naval Academy, Annapolis, MD

If you would like your presentation included in the 75th MORSS Final Report CD it must:

1. Be unclassified, approved for public release, distribution unlimited, and is exempt from US export licensing and other export approvals including the International Traffic in Arms Regulations (22CFR120 et.seq.),
2. include MORSS Form 712CD as the first page of the presentation and
3. a MORSS form 712 A or B must be in the MORSS Office no later than **14 June 2007**.

Author Request (To be completed by applicant) - The following author(s) request authority to disclose the following presentation in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORSS web site.

Name of Principal Author and all other author(s):

Michael P Bailey

Principal Author's Organization and address:

3300 Russell Rd, Quantico, VA 22134

Original title on 712 A/B:

Validation Methodology for Agent-based Simulations

(Please use the same title listed on MORSS Form 712 A/B. If the title was changed please list the revised title below.) Revised title:

Presented in: WG(s) # 33 CG _____, Special Session _____,

Demonstration, _____, Tutorial, _____ or Focus Session # _____

The following presentation is believed to be: unclassified, approved for public release, distribution unlimited, and is exempt from US export licensing and other export approvals including the International Traffic in Arms Regulations (22CFR120 et.seq.)

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 01 JUN 2007		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Validation Methodology for Agent-based Simulations				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USMC 3300 Russell Rd, Quantico, VA 22134				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM202526. Military Operations Research Society Symposium (75th) Held in Annapolis, Maryland on June 12-14, 2007, The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 14	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



VALIDATION METHODOLOGY for AGENT-BASED SIMULATION



AkstAltAxtellBaileyBarryBeanlandBlaisBottomClarkClemenceDavisDuncanDuongEbert
hEspinosaHenscheidHollandHornellachinskiJacksonKaneKoehlerLiesnowitzLucasLyle
MacallMcDonaldMcGaugheyMeyersMiddletonMiddletonMoyaNicholsParkRauschRogins
kiSaundersSheldonStarrSteinerSteinerStephensStutzmanVaneVernaViscoWangWeisel
WongWorksYilmazYoungYoungbloodYuZandbergen



ABOUT ABSVal

- ***WHICH SIMULATIONS*** are the target of interest
 - Directly applicable to IW problem set
 - In addition to ISAAC, Pythagoras, MANA, consider decision rules, knowledge-based systems, cellular automata, population dynamics
- **Discussion about VV&A**
 - Goal of validation: Match Tool to Application
 - Conservation of Vagueness: definition of “*match*”
- **DoD definitions & Processes**
 - Looking at UK MOD, AIAA, ASME, NASA, DOE
- **Two phases**
 - This phase: What we need to know to evaluate an ABS
 - Next Phase: Experiment with methods



ABOUT ABSVal

- **WHICH SIMULATIONS** are the target environment
 - Directly applicable to IW problem set
 - In addition to ISAAC, Pythagoras, MANA, consider rules, knowledge-based systems, cellular automata, population dynamics
- **Discussion about VV&A**
 - Goal of validation: Match Tool to Application
 - Conservation of Vagueness: definition of “*match*”
- **DoD definitions & Processes**
 - Looking at UK MOD, AIAA, ASME, NASA, DOE
- **Two phases**
 - This phase: What we need to know to evaluate an ABS
 - Next Phase: Experiment with methods

lots of attention

little attention



Schism

- **Agent-based simulations use modular rules and local reasoning to produce realistic and/or interesting emergent aggregate behavior.**
 - **Surprise is good****
- **Successful simulation testing (core to face/results validation) based on demonstrating credibility across the range of potential input.**
 - **Surprise not good****

**** Refined later in this talk**



Questions

- What activities can I reasonably support with my ABS?
- What are the limits?
- What caveats are necessary?
- Compared with traditional simulation solutions, how are my results to be used?
- How can I make credibility statements about a simulation that is out of my (top-down) control?
 - Value of training experiences
 - Value of analytical results
- Can I support the scientific method with this ABS?



ABSVaI Products

- **General, institutionally acceptable processes and criteria for assessing the validity of an agent-based simulation used as part of a DoD-level analysis**
 - **What information?**
 - **What assurances and endorsements?**
 - **What desirable qualities?**



Benefit

- Increased awareness of the value of analysis results supported by agent based simulation(s)
- **[Potential]** Increased credibility of results
- **[Potential]** More valuable agent-based simulations
- **[Potential]** Responsible analytical application of ABS by OA professionals
- **[Potential]** Civilization of the discourse concerning ABS-generated analysis results

Benefactors: HBR, VVA, All Military Organizations using ABS, Analysis, Planning, Experimentation, Training, Acquisition, ...



First Principles

GOAL OF SIMULATION

- a) Aggregate effects you understand
- b) Calculate probability of simultaneous/sequential events
- c) Challenge user's intuition**

DATA

- a) Model exists because of the data
- b) Data exists because of the model
- c) Accuracy, precision
- d) Covering the possible truths
- e) Propagating uncertainty & model sensitivity analysis

SEEING THE INSIDE AND OUTSIDE

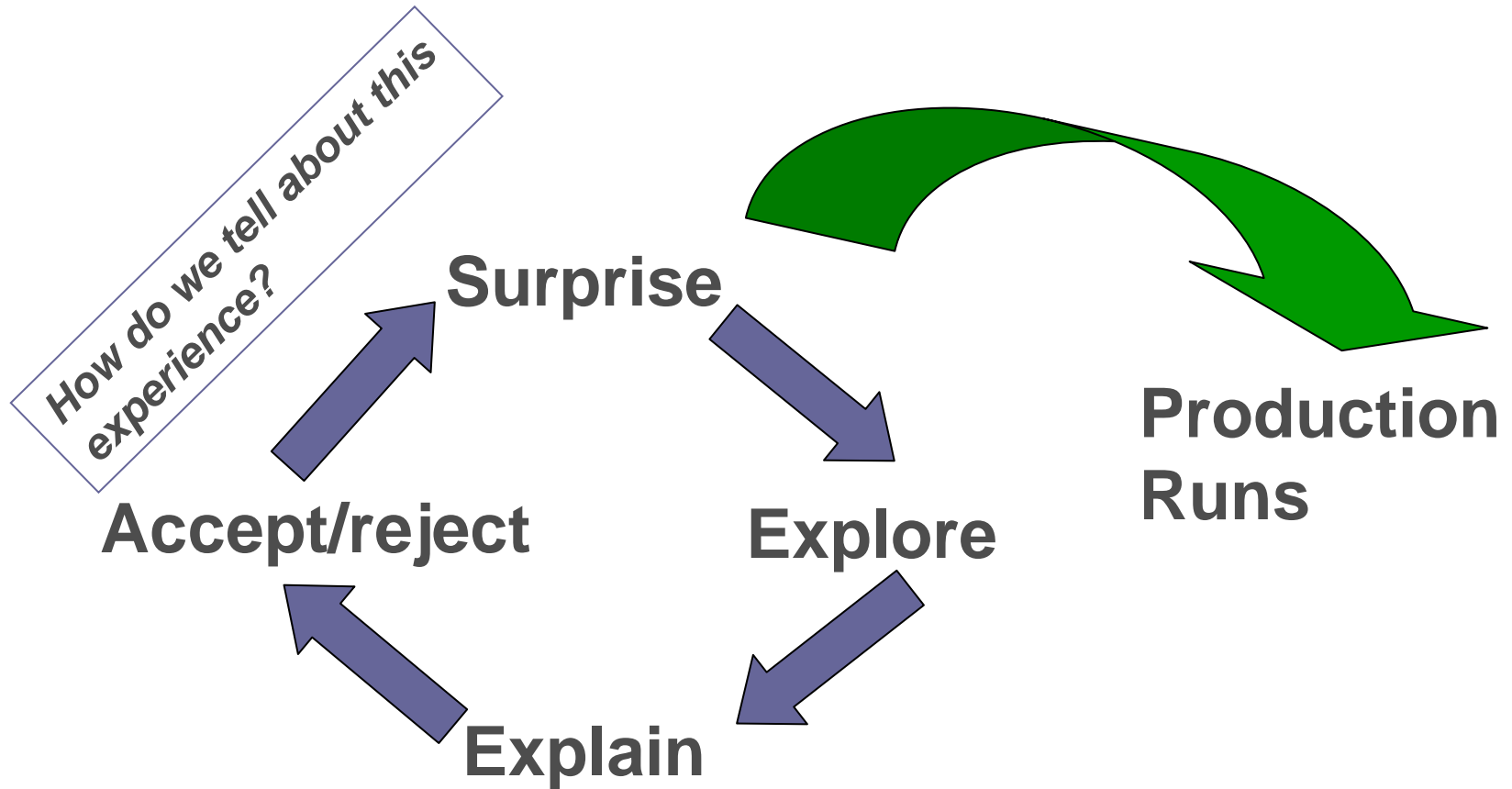
- a) Depict agent's behavior
- b) Depict aggregation methods
- c) Serial aggregation (building blocks)
- d) Prose, pictures, diagrams, tests
- e) Visualization of outcomes, trends, cause-effect

VALIDATION SURROGATES

- a) History of successful uses
- b) Credible believers
- c) Large, mature user community
- d) Transparency
- e) Relative validity
- f) (Over-?) Fitting historical data



Surprise!



What abstractions, data values, shortcuts, tricks, intentional oversights, modifications to expectations, code changes **were required?**



Representation

- **Dynamic Influence**
 - 1st-order effect
 - Direct influence
 - Relevant over large interval
 - Plausibly relevant over limited interval
 - Possibly influential
 - Minor detail
 - No relevance
- **Distillation**
 - Include only the highly-relevant dynamics
 - Aggregation of effects
 - Referent often loose/missing

**Completeness
vs. Parsimony**



Statistical Methods

Balance Predictiveness vs. Parsimony

- x_i 's are the levels of dynamics included/excluded (capacities)
- Y is the response variable (utility)
- $Y = f(x_1, x_2, \dots, x_n)$
- $DI = \frac{SSE_{\text{with}}/df}{SSE_{\text{without}}/df}$

**Qualitative
assessment
meets
Critical Values**

Bailey, M. P. and W. G. Kemple. 1994. The Scientific Method of Choosing Model Fidelity, *WSC Proceedings*.



Goals

- Understanding the meaning of *Valid Enough*
- Techniques for uncovering validation shortcomings
 - in the presence of a weak referent
- Expressing validation boundaries
- Being conservative with VV&A resources
- Framework
 - transparent, traceable, repeatable, communicate-able



In Sum

- **Achieve the Goals of Simulation Validation for ABS**
 - **Concentrate on analytical applications**
 - **Test-case-driven & practical**
 - **Institutional acceptability**
 - **Vast collection of potential partners**